Chemistry I: Percent Composition and Formula Determination Steps

To calculate the molar mass of a compound:

1. Add up the atomic masses of all of the atoms of each element in the compound. This number will be in atomic mass units (amu). Since we cannot weigh atoms in amu's; we simply convert amu's to grams. This is called the gram-molecular or gram-formula weight of a substance. This happens to be the mass of one mole (hence called molar mass) of that substance. A mole is a unit of measurement that chemists use to measure the amount of matter. A mole of anything has 6.02×10^{23} particles. These particles can be atoms, ions, or molecules. Since we cannot count out such a large number we simply weigh the substance (compounds or elements) in grams.

To calculate the percent composition of a **component in** a **compound:**

1. Find the molar mass of the compound by adding up the masses of each atom in the compound using the periodic table.
2. Calculate the mass due to each element in the compound that you are solving for by adding up the mass of these atoms.
3. Divide the mass due to each element by the total molar mass of the compound and multiply by 100.

$$\text{Percent Composition} = \frac{\text{mass of specific element}}{\text{molar mass of compound}} \times 100\ \%$$

Steps for Determining an Empirical Formula

Empirical Formula-A formula that gives the simplest whole-number ratio of atoms in a compound.

1. Start with the number of grams of each element, given in the problem.
If percentages are given, assume that the total mass is 100 grams so that the mass of each element = the percent given.
2. Convert the mass of each element to moles using the molar mass from the Periodic table.

3. Divide each mole value by the smallest number of moles calculated.

4. Round to the nearest whole number. This is the mole ratio of the elements and is represented by subscripts in the empirical formula.
    - o If the number is too far to round (x.l ~ x.9), then multiply each solution by the same factor to get the lowest whole number multiple.
    - e.g. If one solution is 1.5, then multiply each solution in the problem by 2 to get 3.
    - e.g. If one solution is 1.25, then multiply each solution in the problem by 4 to get 5.

Once the empirical formula is found, the molecular formula for a compound can be determined if the molar mass of the compound is known. Simply calculate the mass of the empirical formula and divide the molar mass of the compound by the mass of the empirical formula to find the ratio between the molecular formula and the empirical formula. Multiply all the atoms (subscripts) by this ratio to find the molecular formula. (See Example #2)

For any kind of molecular compound, we can write:

Molecular weight = *n* * empirical formula weight

where *n* is the number of empirical formula units in a compound. We can get the molecular formula by multiplying the subscripts of the empirical formula by whatever *n* is.

We can calculate this from the equation: n = (molecular weight)/(empirical formula weight)

Sample Problems:

Empirical Formula determination:

The mineral fluorite has been found to have the following chemical composition:

51.34% calcium and 48.66% fluorine

What is the empirical formula for this mineral?

$$Ca = \frac{51.34g}{40.0g} = 1.28$$

$$F = \frac{48.66g}{18.9g} = 2.57$$

$$Ca_{\frac{1.28}{1.28}} F_{\frac{2.57}{1.28}}$$

CaF_2

Molecular Formula determination

What is the molecular formula for a compound with a molecular weight of 58 g and an elemental composition of 82.8% carbon and 17.2% hydrogen?

$$C \Rightarrow \frac{82.8g}{12.0g} = 6.9 \qquad H \Rightarrow \frac{17.2g}{1.0g} = 17.2$$

$$C_1H_{2.5} \Rightarrow 2(C_1H_{2.5}) \Rightarrow C_2H_5$$

molar mass of C_2H_5 = 29 g $\qquad \frac{58g}{29g} = 2 \qquad$ SO: $2(C_2H_5) \Rightarrow C_4H_{10}$

Percent Composition Completed_____

Calculate the percent of each element in the following minerals.

1. galena PbS	7. molybdenite MoS_2
2. cinnabar HgS	8. cuprite Cu_2O
3. covellite CuS	9. pyrite FeS_2
4. nickeline NiAs	10. uraninite UO_2
5. millerite NiS	11. siderite $FeCO_3$
6. rutile TiO_2	12. chromite $FeCr_2O_4$

13. pyrargrite Ag_3AsS_3

14. cryolite Na_3AlF_6

15. kyanite Al_2SiO_5

16. proustite Ag_3AsS_3

17. jamesonite $Pb_4FeSb_6S_{14}$

Empirical Formula Determination COMPLETED_____

Determine the formula of each of the following minerals given their percent composition.

1. zincite 80.34% zinc and 19.66% oxygen

2. fluorite 51.34% calcium and 48.66% fluorine

3. realgar 70.10% arsenic and 29.9% sulfur

4. cassiterite 78.76 % tin and 21.23% oxygen

5. chalcocite 79.87% copper and 20.13% oxygen

6. acanthite 87.1% silver and 12.9% sulfur

7. millerite 64.84 % nickel and 35.16 % sulfur

8. chalcopyrite 34.6% copper , 30.52% iron and 34.88% sulfur

9. kyanite 33.33% aluminum, 17.28% silicon, and 49.40% oxygen

10. bournonite 42.4% lead, 13.0% copper, 24.94% antimony, and 19.66% sulfur

11. proustite 65.45% silver, 15.15% arsenic, and 19.40% sulphur

Molecular Formula Worksheet Completed_____

Determine the correct molecular (true) formula for the following compounds.

1. The percentage composition of a certain gas is nitrogen, 46.6%; oxygen, 53.4%. Calculate its simplest formula. Its correct molecular weight is 30. What is the molecular formula?

2. A compound is composed of 82.4% nitrogen and 17.6% hydrogen. Its correct molecular weight is 17 grams. Find its correct molecular formula.

3. Hydrazine, a high-energy fuel, is found to contain 87.5% nitrogen and 12.5% hydrogen. Calculate its simplest formula. Its correct molecular weight is 32. What is its correct molecular

4. A sample of calcium carbide is analyzed and found to contain 62.5% calcium and 37.5% carbon. What is its simplest formula? If the correct formula weight is 64, what is its correct formula?

5. A compound, composed of 5.9% hydrogen and 94.1% oxygen, has a molecular weight of 34. Calculate its correct molecular formula.

6. A compound, composed of 40.00 % carbon, 6.71 % hydrogen and 53.29 % oxygen, has a molecular weight of 180 grams. . What is the molecular formula?

7. A hydrocarbon is 84.25 % carbon and 15.75 % hydrogen and has a molecular weight of 114 grams. What is its molecular formula?

8. A hydrocarbon has a composition of 92.3 % carbon and 7.7 % hydrogen. If the molecular weight is 78 grams what would be the molecular formula for this compound?

9. Elemental analysis of a compound found the following: carbon 40.0%, 6.6% hydrogen and 53.3 % oxygen. If the molecular weight of this compound is 60 grams; what is the molecular formula?

10. Nutrasweet has the following elemental composition:

57.14 % carbon
6.16% hydrogen
9.52% nitrogen
27.18% oxygen

If the molecular weight is 294 grams, what is the correct molecular formula for this compound?